SECRET

COR-0906
Copy 1 of 4
23 August 1960

MEMORANDUM FOR: Director PIC

THROUGH : Acting Chief, DPD

25X1A ATTENTION : [redacted]

25X1A SUBJECT : [redacted] Second Report on Project [redacted]

25X1A 1. Attached is a copy of [redacted] Second Interim Report on 25X1A their study of SAC PI Technique.

2. This is furnished for your information only and upon review it is requested that the Report be returned to this office.

25X1A [redacted]
Chief, Contracts Branch, DPD

1 Attachment
As stated

SECRET

COR- 0903
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STATINTL

PROJECT [redacted]

Second Interim Report

19 May - 18 July 1960

Submitted b [redacted] STATINTL

[redacted]

25X1A

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I. INTRODUCTION

This interim progress report summarizes activity on "Project [redacted] during the period 19 May - 18 July 1960. During this period, activity was concentrated in conducting test programs in the photo and photogrammetric areas, several Alwac computer programs were modified and written, and a detailed analysis was made of the 544th's library problem. Also during this period, an analysis was initiated to determine the impact of future photo inputs on the capabilities and operation of the 544th RTGp and related units. The final results and recommendations resulting from these tests and analyses will be submitted in the final report scheduled for completion on 30 September 1960.

During this period, a critique was conducted of the first interim report submitted by Itek on this project. In general, the report was accepted with only minor correction, with the exception of the planned program in the photointerpretation area.

A report of a special meeting held to discuss and decide the extent of [redacted] participation in the PI area is included as Appendix E. It was agreed at this meeting that [redacted] effort would be redirected to PI effort outside of the Research Center. A preliminary evaluation in this area was conducted and the extent of [redacted] possible contribution is under review.

II. SUMMARY

A. Photogrammetric Equipment and Techniques

The information presented in this second interim report is primarily concerned with the control extension tests conducted by the Mensuration Branch. The sources of error, the means of computing the magnitude of the error and the method of applying the error to the fiducicious photographic coordinates are discussed in detail. The effect of these errors on the final positional accuracy of test points has not yet been fully analysed. The completed computational data has been received and is being analysed at this time.

A proposal for training Beta II operators is presented with some of the possible means of implementing such a training program. The lack of trained operators is considered the major weakness in the extensive use of this instrument in the work of the Research Center.

Two methods for tilt computation other than the presently used Church, single photo, method are proposed. The use of these methods, each with different input requirements, may help alleviate the control availability problem in some areas of the world.

Some basic information on the organization and operations of PRSD is presented in a report of a visit to that organization. It is pointed out that a better communication tie is required between the user and the search team if the most advantageous use is to be made of the services and capability of PRSD.

B. Photographic Equipment and Techniques

The major effort during this reporting period has been directed toward a study of the effects of the various photographic printers on resolution and image quality during several generations of prints. The methods of testing and the proposed method analysis is discussed in detail. Inasmuch as all of the test exposures have not been evaluated, a complete analysis of results will be presented in the final report on this project.

C. Photogrammetric Computer Programs

Some modifications to existing computer programs are presented. These are modifications to programs previously prepared by Broadview Research Corporation and are concerned mainly with panoramic type photography. These modifications are directed toward the input-output functions and present a method for easier address by the equipment of the Research Center.

In addition to these modifications, a general introduction to a new program is presented. This program provides capability for plotting panoramic coverage on a chart. The program has not been completely debugged at this time. A complete program description will be presented with the final report of this project.

D. Data Handling Problems Within The 544th RTGp Research Center

A survey was made of the files of information existing in the Research Center. A general system for handling these files was devised

which would use available Research Center data processing equipment. The basic filing methods proposed are similar to those in existence now, may changes being toward more complete mechanization or toward provision for future file growth. The Research Center function is not a library one, and therefore the files maintained are not large ones. The primary function is to support special local operations which cannot be satisfied by the Data Center.

In addition to the file survey, a study was made of the possibility of automatically producing local indices using data already prepared by outside sources, primarily the Data Center. Such indices might provide knowledge of what information is available more rapidly than with existing methods.

Another study considered the possibility of the automatic production of indices from data obtained in the compilation of the Mission Review Report. The problems encountered in normal indexing seem to be minimized because the reports have a definite "style" and are not subject to the ambiguities of normal discourse such as that appearing in other types of intelligence.

The basic problem underlying all of the above effort is the problem of handling textual information. A general system was devised which will accomplish this to a more or less satisfactory degree. The system was only specified in coarse detail so that it might encompass all of the problems. For those problems worthy of further study, a detailed system can be planned, and a simulation or test performed.

The numerical data handling problems encountered in photogrammetric work were studied in the light of the Research Center computer facilities. Recommendations for writing a program compiler and a program translator were made on the basis of a sizeable anticipated growth in computer work load.

III. GENERAL ACTIVITIES DURING THE SECOND INTERIM REPORT PERIOD

Again during the second report period, all members of the Project [STATINTL] team have spent considerable time in the Omaha area in technical conferences and working with personnel of the 544th RTGp. A general listing of these conferences and other activities is presented here.

23 May-- 6 June — This time was expended by all members of the team in preparation of the first interim report.

[STATINTL] June — [redacted] arrived in Omaha and submitted the first interim report for the period 18 April to 18 May 1960.

[STATINTL] 8 June — [redacted] were exposed to a simulated P. I. exercise in the Photo Evaluation Branch. The exercise was conducted using two year old photography that had previously been evaluated. Serious doubt arose as to the validity of the simulation.

[STATINTL] Week of 6 June — [redacted] conducted an operational and maintenance training program at [redacted] for the Mark I Mensuration Viewer. [STATINTL] Captain Gibbs and Airman First Class Fortin of the 544th RTGp attended.

[STATINTL] 14 June — [redacted] attended a critique of the first interim report. The critique was conducted by Lieutenant Colonel McCash, Major Anderson of the Directorate of Intelligence and Colonel Ainsworth, Lieutenant

Colonel Tighe and Major Callanan of the 544th RTGp. With the exception of the photointerpretation area, which was deferred for special discussion on 15 June, the report was accepted with only minor exceptions.

STATINTL 15 June A meeting was held to resolve the question of [redacted] efforts in the special photointerpretation area. In attendance were [redacted] of [redacted] Colonel Krause, Lieutenant Colonel McCash and Major Anderson of the Directorate of Intelligence and Lieutenant Colonel Tighe of the 544th RTGp. It was agreed by all parties that without unrestricted access [redacted] would be unable to carry out its proposed study in the special photointerpretation area. Because existing security restrictions prevent this it was decided that this portion of the study would be deleted from the Itek work statement.

STATINTL 16-17 June [redacted] conducted an intensive photographic test program in the Special Projects Laboratory. This test consisted of printing special resolution targets and photometric areas through five generations of the CP-18, C1B and EN-1 printers. Also selected generations were enlarged at several levels on the Wild Enlarger. It is estimated that three to four weeks will be required to analyse all of the test data collected.

Week of 13 June STATINTL initiated collection of necessary data to conduct analytic aerotriangulation tests in the Mensuration Branch.

20--23 June STATINTL in Omaha to complete details of analytical aerotriangulations, availability of computer time, personnel etc.

22--24 June STATINTL in Omaha to conduct Phase II of the photographic tests in the Special Projects Laboratory. These tests consisted of printing and enlarging selected frames of original negatives from a recent "Project STATINTL flight. These negatives were run through five generations on the CP-18, EN-1 and C1B printers and selected areas enlarged on the Wild Enlarger. Glass plates were also printed from selected generations for mensuration tests. Further, high contrast resolution targets were duplicated on the 70 millimeter contact duplicator.

It is anticipated that the results of the Phase II tests will be closely correlated to the resolution tests previously conducted.

STATINTL
27 June STATINTL initiated computations for error coordinates for aerotriangulation tests.

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29--30 June STATINTL visited ACIC - PRSD in Washington, D. C. for additional information regarding availability of specific

photo coverage and system for handling it. Also visited SAC 544th RTGp Detachment I for review of search and ordering techniques.

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30 June [redacted] visited the 8th RTS at Westover Air Force Base. A thorough tour and briefing of the activities and equipment of the Photo Lab, Reproduction and Cartographic Branches and the Intelligence Library was conducted.

STATINTL

Week of 27 June [redacted] completed the writing of a report on the following:

a. Analysis Center Technical Library

b. Analysis Center Intelligence File

20 June--1 July Analysis of test data collected during the Phase I photographic tests in the Special Projects Laboratory was begun. Analysis was conducted under the direction of H. [redacted] by the Photographic Department of [redacted]

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20 June--1 July [redacted] in Palo Alto initiated the following:

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a. The writing of a program which will allow the user to construct graphic plots showing the photo coverage obtained for a particular photo mission.

b. Further investigation of:

(1) Program for the Numerical Rectification

of Panoramic Photography

(2) Three Richardson Subprograms

(3) Program for Orientation Determination from Horizon Images.

STATINTL 5--8 July [redacted] completed error computations for analytical aerotriangulation tests and forwarded same to Omaha.

STATINTL 5--8 July [redacted] in Palo Alto continued writing of program for Graphic Plotting of Photo Coverage.

STATINTL 11--14 July [redacted] in Omaha for completion of the analytical aerotriangulation test computations. Tests were completed on 14 July. Results to be reviewed and forwarded to [redacted]

STATINTL [redacted] during week of 18 July.

STATINTL 12--14 July [redacted] in Omaha for debugging of the program for Graphic Plotting of Photo Coverage. Also completed interim report on further description of input - output characteristics for the following Alwac III E programs:

a. Numerical Rectification of Panoramic Photography

b. Three Rachardson Subprograms

(1) Reference points

(2) Local points

(3) Distances

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c. Orientation Determination from [redacted]

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STATINTL 13--14 July [redacted] in Omaha discussed with Colonel Krause, Lieutenant Colonel McCash and Major Anderson of the Directorate of Intelligence the requirement for consideration of future photographic inputs as a part of the "Project [redacted] study. It was generally agreed that some consideration should be given to the impact of future inputs (e.g. E-5) on existing and programmed capabilities (techniques, equipment, personnel training etc.) as described in the [redacted] work statement and discussed in the first interim report.

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14 July A tour of the Cartographic Branch was conducted by Major Cobb for [redacted]. A detailed description was given of techniques and equipment used in the production of Series 200 Target Charts. Radar charting techniques were also discussed.

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5--15 July During this period the analysis of the Phase I photographic tests conducted in the Special Projects Laboratory were completed. Analyses of the Phase II tests were initiated. Additional tests to be conducted on the Special Projects 10/70 printer are tentatively scheduled during the week of 25 July.

STATINTL

5--15 July During this period [redacted] completed writing a report on the following:

a. Conversion of Data Center Index Data to Local Index for "High Use" Information.

b. Use of Mission Review Report in Automatic Indexing of Photointerpretation Reporting.

c. Mechanization of Textual Information Handling Problems in Research Center.

d. Programming and Computer Usage.

IV. PHOTOGRAMMETRIC TECHNIQUES AND EQUIPMENT

A. Background and Introduction

In the first interim report on Project [redacted] STATINTL [redacted] STATINTL recommended a series of tests to determine the sensitivity of one method of analytical control extension to the input error magnitudes to be anticipated. The method to be tested was the Herget extension method with tests to be run on the Recomp II computer. As many of the applicable error factors as possible were to be considered in an extension covering a distance of approximately 30 miles.

During the second reporting period [redacted] STATINTL was also to look further into the various applications of the Beta II Stereoplotter to the operational problems of the 544th RTGp. This first order opto-mechanical stereoplotter is extremely capable and should provide a real capability for preparing graphical information in a form usable to SAC.

In a search for further background information on the type and history of the film to be anticipated in the operational problems encountered by the 544th RTGp., a visit was conducted to the ACIC-PRSD in Washington. A detailed report of this visit is included in this report.

In a recent photogrammetric problem area, it was determined that the present methods of tilt determination for rectification were not always applicable due to lack of certain basic input information. [redacted] STAT was requested to investigate the possibility of another or several other methods of tilt determination which may fit the special requirements of this operational activity more completely. It may be necessary to develop and

program a series of methods for the differing situations which may arise.

B. Present Status of Control Extension Tests

The plan of tests proposed in the first interim report were approved essentially as presented. It was determined that basic test data were available at the Research Center of the 544th RTGp and that with very minor modification. these test data could be used for the proposed tests. The existing program for the Herget method was utilized on the Recomp II computer for these extension tests. The method of determination and approximate magnitude for each of the error components is described below.

1. Focal Length Error--The nominal focal length of much of the reconnaissance photography in use today is 6 inches. However, the manufacturing tolerance of this lens were such that the focal length varied between 150 and 156 millimeter. In some instances, a calibrated focal length may be indicated. However, in the majority of cases, the focal length will simply be stated as six inches. It was considered that an error of plus or minus 3 millimeters might be encountered in the utilization of this nominal 153 millimeters or six inch focal length. Therefore, the complete thirty mile extension was accomplished using a focal length error which was an error by 3.000 millimeters. Only the plus value of this focal length error was used since it was considered that the minus value would have the same numerical results. Only the signs of the values would be changed.

2. Lens Distortion--The distortions present in the six inch metrogon lens are basically tangental distortion and radial distortion. Of these the radial distortion is usually of an order of magnitude higher than the tangental distortion. Therefore only the radial distortion was considered in this test. The radial distortion is that error in the lens manufacture which tends to move the imaged photographic point toward or away from the principal point of the photograph. In this case we selected a nominal distortion curve for a series of metrogon lenses. This distortion is zero at the principal point, reaches a peak of approximately 0.20 millimeter at 33° from the axis, turns downward and crosses the zero line and is a negative maximum of approximately 0.20 millimeter at 45° from the optical axis. The actual values assigned to this curve were taken from the Manual of Photogrammetry. It is known that the metrogon distortion varies through quite a wide tolerance, however it was felt that this nominal distortion curve would give the best indication of the errors to be encountered when using photography from an uncalibrated type camera. In order to determine the effect of this lens distortion on the x and y photographic coordinates, the radial distance from the principal point was first determined. This distance was then distorted by its value in accordance with the distortion curve and the new x and y photographic coordinates for each of the points were determined.

These erroneous photographic coordinates were read into the computer tape and the extension completed for the thirty mile strip.

3. Control Point Identification Error--It is considered that in certain areas of the world the location of a control point which has only been described in words will be extremely difficult if not impossible to identify on the photograph. Many of these points are not indicated on the available map coverage and their location must be determined entirely from a verbal description. In the areas where control of this type is available it was indicated by personnel of the 544th RTGp. that the probable identification error would be approximately 40 feet. This could mean a 40 foot error factor introduced in any direction. To determine the effect of such an error on our test, the three basic control points at the start of the flight strip were misplaced by 44, 41, and 35 feet on the ground. These intentionally introduced errors were then computed to determine their effect on the x and y plane coordinates of the photographic measurements. The photo measurements were then changed to reflect this error and with these new photographic coordinates the entire flight strip was recomputed to determine the effects of this control misidentification on the final position of the test points.

4. Measurement Error--Three basic factors are combined for making up

the indicated measurement errors. These are (1) the mechanical accuracy of the measuring instrument; (2) the accuracy of stereoscopic transfer of points from one photograph to another; and (3) the pointing error of the operator using the measuring equipment. Previous tests and use of the Nistri TA3 Stereocomparator have indicated an instrument accuracy of plus or minus five microns. Extensive testing both in Europe and the United States have indicated that stereoscopic transfer of points by any one of the several methods available will result in an error of plus or minus 25 microns in point location. It has been determined that the pointing to a position by an operator can vary from operator to operator and from point to point by approximately plus or minus 10 microns. These three sources of error combine to give us a mean square error of approximately 27.3 microns in each of our x and y photo coordinates. Of course these errors will be non-systematic in nature. In order to insure random distribution of the error, a normal distribution curve was used with a table of random numbers and a lottery type distribution for the selection of these numbers in order that the result of mean square error would be 27 microns. In this case the maximum error was three times the mean square error. Here again, when the distorted x and y photo coordinates were computed, they were used in the computation to determine the position of the control check points at the end of the thirty mile extension.

5. Film Shrinkage--It is known that the film base normally used in aerial photography changes dimension during processing and after processing during long periods of storage time. The Manual of Photogrammetry lists several film bases with their coefficients of expansion both across the film and along the length of the film after one year of storage. Although it is impossible to make a general statement as to the type of film base which will be available for the coverage in the area of interest, that base which would give the maximum distortion was selected. This was the old tri-acetate base later known as recon base film by Eastman Kodak. It was determined that the film after one year of storage had a shrinkage across the film of 0.4 per cent and along the film of 0.3 per cent giving a differential contraction of 0.1 per cent. The coordinates on each of the photographs were modified to this indicated film shrinkage and new photo coordinates were again utilized to compute the positions of check points at the end of a thirty mile extension.

6. Principal Point Displacement--The fiducial marks in the reconnaissance type cameras in use during and immediately after World War II had the fiducial marks mounted in the film magazine. Inasmuch as this was a separate mechanical unit from the lens cone mounting, these fiducial marks did not indicate the true optical principal point. In conversations with STATINTL [redacted] STATINTL [redacted] it was indicated that the

principal point of these cameras, as indicated by the fiducial marks, may be an error by as much as 2 millimeters on the focal plane. Consequently the photo coordinates again were shifted by this error magnitude of 2 millimeters and the resultant distorted values were again used in the computation to determine the effects of the principal point displacement on the accuracy of position determination at the end of the 30 mile photographic strip.

All of the tests described above have been completed on the Recomp II computer by personnel of the 544th RTGp. and the errors encountered in ground position have been tabulated. A more detailed analysis of these errors will be available for the next reporting period. The very preliminary investigations indicate that, when all of the errors are combined in a single extension the resultant error will exceed the 1000 foot CPE which had been set as a goal. However, the error does not appear to exceed 1000 feet by a large factor. A more definite resultant will not be available until after a complete evaluation of the tests and will be reported in the final report on this project.

C. BETA II - Stereoplotter

In addition to the analytical capabilities of the Research Center of the 544th RTGp. there is available also the Beta II - Stereoplotter which provides this unit with an opto-mechanical plotting capability which can, under certain circumstances, be used to extend control or to draw detailed

maps of small areas within stereo models. This is one of the many instruments which has been developed sepcifically for topographic mapping uses throughout the world. Its use therefore is more or less limited to the specific types of inputs which mapping organizations have developed over the years. In general these require that the diopositives be printed on glass plates, the camera will have a six inch focal length (although the 12 inch focal length cones are available to the 544th RTGp.). The photographs will be either vertical or near vertical, with possibly a set 20° of tilt for convergent photography. The calibrated focal length and all other metrical information regarding the camera will be known.

Many of these factors will not be known in the work of the 544th RTGp. However if an area falls within one or two stereoscopic models and this area is of particular interest to the Strategic Air Command it may be possible to utilize the Beta II for drawing a detail map of the target complex. The Beta II stereoplotter is a first order instrument. That is, it is an extremely accurate piece of equipment. The operation of this instrument although similar to any of the other stereoplotting equipment in use throughout the world today, does require extensive training on the part of the operator. Therefore in order to utilize this equipment either in its fully capable intended use of control extension or for the development of large scale small area plans or maps, it will be necessary to train an operator. It is understood by members of the Mensuration Branch of the 544th RTGp. that training on this instrument is difficult to obtain where

the instrument is in every day use. Two courses of action appear to be open along this line at the present time. One is to obtain operator training services from the [redacted] The second is to establish a training program for the personnel of the 544th at Omaha. This will be a relatively difficult task and it is recommended that it be carried out in a number of finite steps.

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Since the theory of photogrammetic steroplotting equipment applies equally well to the simple projection instruments and the more complex first order instruments it is desirable to train a beginning operator on one of the simple projection type equipment such as the multiplex or Balplex. It is understood that since the Kelch plotter, the AMS-2 plotter and the Balplex plotters are coming into use at the Army map service, that a number of the older style multiplex bars may be available for training purposes. Only one such bar would be required. This bar and its equipment would consist of the one bar, a plotting table, two or three multiplex projectors, and the multiplex tracing table. With this instrument set up and in operation it would be possible to demonstrate to the trainees all the motions which are inherent to the Beta II instrument and it would be possible for the trainees to see results of these motions far easier than it is with the Beta II instrument. It is believed that a four week training period on the multiplex would equip the operators to more readily absorb the training on the Beta II steroplotter.

D. Alternate Analytical Tilt Solutions

It has been noted that the Church space resection method, utilizing

three control points, has been used exclusively for the determination of the orientation of single aerial photographs in order that these may be rectified for mensurational use. In many instances the accuracy of control available for this analytical tilt solution is not sufficient to provide a precise answer. In other words the system is predicated on the availability of precise horizontal ground control. Where such control consists of the measured coordinates of some points indicated on extremely poor quality maps, the tilt analysis resulting from these computations will not be firm. There are other methods of tilt determination which may be used in the event that the specified ground coordinate data is not available.

1. One such method was developed by Church at Syracuse University and is outlined in detail in Bulletin Number 19 of the photogrammetric series from Syracuse University. This bulletin is on file in the technical library of the Mensuration Branch, Research Center of the 544th RTGp. This method uses two overlapping photographs and simply the photographic measurements themselves plus some general ground elevations to determine the tip and tilt of the two photographs in question. No horizontal ground control is required for this analysis. This analysis has not been programmed for either the Alwac or the Recomp II at this time. However such a program should not be difficult to write and it would provide an additional capability covering those times when the horizontal ground control is not available for the single photograph method.

2. Another method which was developed by Church is the tilt determination without any ground control whatsoever. This system requires four overlapping photographs, two from each of two overlapping flight strips. In the case of reconnaissance photography such a setup may seldom be found in practice, however if such a case is available then this method may be used to determine the tilt of the photographs when no ground control whatsoever is available in this area.

E. Investigative Conference at Photo Records and Services Division

STAT On 29 June 1960 [ ] personnel visited the Photo Records and Service Division (PRSD) of ACIC in Washington. PRSD is responsible for filing and distributing all aerial photography for the Air Force and the Army. The Navy maintains a separate film storage unit. The film which PRSD has is actually stored at Vint Hill, near Warrenton, Virginia. The photographic laboratory is also at the Vint Hill location. The files of PRSD contain approximately 130,000 cans of film. In addition to these rolls of film there are approximately 1.25 million sheets of cut film, and 7-1/2 million paper prints within the library system.

The library is organized by country name. A Country Photo Index (CPI) is prepared for each country with overprints showing the general area covered, the type of photography, the taking agency, the approximate scale of the photography, and who holds the original film. These CPI's are available to all armed service agencies. For more detailed information and the ordering

data the Standard Indexing System (SIS) acetate plot sheets are used. There are approximately 9 million SIS plots in the library covering 9,000 degree squares of the earths surface.

Most agencies using PRSD maintain a resident search team at the library. The 544th detachment Number I of Washington has such a resident team. These search teams accept the request from the parent organization and search the CPI or SIS plots for photography to fulfill their requests. The requested photographs are printed or duplicate negatives are prepared at Vint Hill. Major Ross, the director of PRSD, indicated that the original film may be loaned from PRSD. However, arrangements for such a loan must be through the parent organization, ACIC of St. Louis. In the case of the use of this film for photogrammetric, analytical control extension operations it would be deemed advisable to obtain the original film wherever possible.

From the numbers mentioned above it is obvious that a general search for all photography covering a certain area is almost impossible. Therefore, it is necessary that more detailed information be given by the requester so that the resident research teams at PRSD can fulfill the request in a logical manner. In many instances, although the requester may have intended to use six inch photography, perhaps better scale coverage of the area is available with a 12 inch focal length camera. The search team at PRSD has no way of knowing that the 12 inch photography will be useless because of its focal length or because of the angular relationships contained within the photograph unless the requesting agent specifically states six inch focal length or what-

ever other parameters are required for his work. It is believed that the more specific information which can be given to the search team at PRSD the better will be the resultant photographs delivered. Further the requester should specify whether he requires paper prints, positive prints on a stable base such as the opaque white material, high quality duplicate negatives to prepare his own glass plates or whether the original negatives would be desirable for use of this specific project at this particular time.

V . PHOTOGRAPHIC EQUIPMENT AND FACILITIES

A. General

A major reorganization of the physical spaces of the Special Projects Laboratory has occurred during the period covered by this report. The plan which was discussed in our first report, providing a much improved work flow throughout the entire area and providing quality control laboratories, has been implemented. At the time of writing, the major part of the new construction, plumbing, and wiring has been completed, and some of the new equipment has been installed and initial tests conducted. By the time this report is printed, we expect that all workmen will be out of the area, and a thorough cleaning will have been done to get rid of the inevitable dust and dirt.

The 20X Precision Enlargers have been installed, and initial tests conducted. Reports from other users of this equipment indicate that very fine results have been obtained with these enlargers, and we recommend that their use with current 9-1/2 inch photography be exploited, working with selected small area dupe negatives made directly from the input positive rolls. For small target areas, occupying less than .45 by .45 inches, it is quite probable that better results will be obtained with this enlarger than with the Wild Enlarger.

The Bar-Ray Glass Plate Processor has been installed, and our impressions are that if the volume is sufficiently high, this machine will be very useful. However, we have seen little indication to date that the volume will be very heavy.

B. Photographic Equipment Tests

A number of detailed tests of Special Projects Laboratory photo equipment have been conducted. With the cooperation of the Special Projects Laboratory personnel, resolution capability tests have been made on all photographic printers (with the exception of the LogEtronic SP 10/70 which was unavailable during this period). The purpose of this series of tests was to obtain data which indicate the degradation that these printers will cause in successive generations. To this end, special 9-by-9-inch target arrays were prepared, which included a total of 13 targets that were specifically limited to a resolution approximating the quality level currently dealt with in the Special Projects Laboratory. Note that these target patterns were not intended to test the ultimate limiting resolution of the printers, but to show what would happen to representative current inputs, when reproduced through several generations.

Tests were made on the following printers,using the targets described above:

LogEtronic CP-18

EN-1

C1-B

Wild VG-1 Enlarger

The tests were conducted in the following manner. All actual photo work was done by the enlisted personnel who normally use the equipment. Developer types and times were consistent with normal practice. Prints

were made at several exposure levels for each generation, and a Wild microscope was used to select the best exposure. The best exposure was then used for the next generation print, and the others were discarded.

On each piece of equipment, prints were carried through five printing stages, to the 6P Print, assuming the original is designated 2P. (On the Wild Enlarger, prints were not made at all six generations, but only at the 2P and 5N stages.) All single frame prints were tray processed, while the C1-B rolls were processed on the Houston-Fearless EN-6. DK-50 developer, diluted 1:1, was used.

Transparencies were made at each generation, and paper prints were made at selected stages. Paper prints were made on the Wild Enlarger, at 2.25X and 4.0X.

After proper identification with printer type and generation, all prints and transparencies, together with the originals, were returned to Boston, where the detailed analysis of results is being conducted. All resolution readings have been completed by three observers, and graphs are being prepared showing resolution over the 9-by-9-inch area as a function of generation. It is too early to report all the quantitative results of these tests. However, indications are that all printers introduced appreciable loss over several generations, even for the case in which the starting 2P resolution was only 38 lines per millimeter. The following table lists the percentage losses encountered through the total of five successive generation of printing, in which the two vertical columns

give the losses for the two different original quality levels of 48 and 38 lines per millimeter.

Printer	48 l/mm Original	38 l/mm Original
EN-1	44%	37%
CP-18	65%	50%
C-1B		
a. Lines perpendicular to direction of motion.	(Not completed)	71%
b. Lines parallel to direction of motion.	(Not completed)	49%

TABLE I

RESOLUTION LOSSES THROUGH FIVE CONTACT PRINTING STAGES

Note that the C1-B shows a very substantial loss in the lines which are perpendicular to the direction of motion. This is a direct result of slippage between the two emulsions at the instant of exposure. Many instances of blur were noted during the reading of these films.

The Wild Enlarger tests indicate that the focal setting is not optimum, since better resolution occurred consistently at the corners than in the center. Even the corner resolution showed a serious loss in resolution from the original levels of 38 and 48 l/mm. We recommend strongly that a careful through focus test be conducted, since it appears that the present setting is not correct. (Data on all these tests will be included in the final report, in the form of plots which show the resolution over the

entire field.)

Tests on the Eastman Kodak 70 mm Roll Film Printer were also conducted, using a different target array in which the resolution level was higher. The analysis is not complete on this test. However, one peculiar problem that arose, and that has not yet been solved, is the marked loss in contrast in the image through each successive generation. Whether this is due to development to a gamma below unity in the EN-6, or whether the printing density of this film (1AG2) is lower in the near ultraviolet spectral region, has not been determined. Further tests will be conducted to determine the source of this marked decrease in contrast. The loss was so great that the results of this particular resolution test must be qualified in reporting the actual resolution figures in the final report.

In addition to the resolution tests described above, an identical set of tests was conducted using representative good domestic photography as the input. In this case, we started with the original negative, and carried through five printing stages to 6P. These transparencies will yield a series of photomicrographs, made in Boston, which will demonstrate the subtle losses in detail that occur through the multiple printing operations. In addition to this straightforward emulsion to emulsion series of printing tests, one test was made in which the 6P was printed from the 5N with the base toward the raw film. This is an operational situation which is encountered at the present time - one which could potentially introduce serious losses with printers that use a diffuse or semi-diffuse light source. The losses will be

much smaller with point source type printers.

The series of photomicrographs from these aerial photographs is now in preparation, and will be included in the final report. In addition to the tests made on film, prints were also prepared on glass plates of the 1N, 3N, and 5N photographic negatives. These will be used to determine the dimensional change incurred through the multiple printing stages. Further tests will be conducted to determine an operator's ability to point to an image edge with a high precision comparator. This will give an indication of the change in slope of the edge gradient. The resultant lowering of measurement accuracy is a very important consequence of lowered image quality.

VI . PHOTOGRAMMETRIC COMPUTER PROGRAMS

A. General Background

During the second report period the efforts of the programming unit have been directed toward programming and debugging a method of plotting panoramic photographic coverage. The program has been completed and has been tested numerically in several conditions; however, debugging has not been completed at this time. Other efforts have been directed toward investigation of ways and means of increasing the operating speed of the program for Orientation Determination from Horizon Images. From preliminary considerations of this program, it was concluded that the speed could be increased by a factor of two by means of a reorganization of the data flow within the program; however, the discovery of a false assumption in this prelininary analysis invalidated that conclusion. Upon closer examination, it was found that very little saving in operating time for a typical program could be achieved. Indeed, for some cases the modified program would require more time. When it was found that this method could not be used for speeding up the operation of this program, other means of program modification were investigated. Throughout this investigation the same analytical formulation of the problem as was stated in the original report has been maintained. These investigations indicate that very little can be done to increase the operating speed of this program on the Alwac III-E. If the entire program were recoded on a minimum latency basis and judicious use made of "preselect" and "one-word-write" capabilities, a time saving of approximately 5 per cent might

result; however, this task would require about two man months of effort for a man thoroughly familiar with the structure of the program as it now exists. Reformulation of the analytical problem may be another avenue of approach; however, experience with the original formulation tends to indicate that the present method of solution involves the least computation for the precision achieved in the general case.

B. Further Description of Input-Output Characteristics of the Three ALWAC Programs

The original programs under discussion at this time were developed for a paper tape input-output to the Alwac III-E computer. These programs were developed by Broadview Research Corporation and are listed below:

1. Program for Numerical Rectification of Panoramic Photography (BRC Report RB-59-2.1047-8)
2. Richardson Sub-Programs (RB-59-;.1052-8-1)
3. Program for Orientation Determination from Horizon Images (RB-59-2.1052-8-2)

The purpose in presenting this more elaborate description is to provide SAC personnel with sufficient information for converting these existing programs to use with IBM card input-output. This conversion is necessary to make the programs more effective in the SAC Alwac computing system.

Detailed descriptions of the program modifications are included in Appendix A, B, and C of this report.

C. Modification of a Program for Space Resection by Least Squares [illegible]

Two minor modifications to the existing space resection program will possibly increase the service of this program to the 544th RTG. For the present application of this program, it is considered desirable to limit the number of iterations the program is allowed to take. Experience with the program should show that in the present work if the solution has not converged after ten iterations there is little likelihood that it ever will. The second proposed modification to the program is this. The converse solution should be calculated after the tilt, swing and azimuth have been computed. The displacements between the given and the calculated control points will serve as a measure of the validity of the answer. Details of the modifications of the input-output subroutines of the program on Least Squares Space Resection are included as Appendix D of this report.

D. Program for Plotting Panoramic Photo Coverage

This section presents a brief, working description of the Panoramic Photo Coverage Program which will allow SAC personnel to design the input-output subroutines which best meet the needs of their system. A more formal program description will be submitted with the final report of this project.

The program (without the input-output subroutines) is stored in channels C1 through CC. Entry to the program is made at channel C4, Word 00, channel C4. Subsequent entries to the input subroutine are made from the instruction pair in word 1A, channel C4. At present, both of these entry instruction

pairs are the same (87CD 1160), using channels CD and CE for the mock input subroutine. Two entries (first and subsequent) are provided to allow for proper handling of card reader feed and buffer cycles on the first and on subsequent input operations.

It is required that the input subroutine take in the data, process and store it in Working Storage II in the following manner:

QUANTITY		LOCATION	UNITS	SCALING
(H)	Height	22	meters	28:4
(λ_n)	Latitude	23	radians	3:29
(θ_n)	Longitude	24	radians	3:29
(d)	Azimuth	25	radians	3:29
(P)	Pitch	26	radians	3:29
(r)	Roll	27	radians	3:29
(Y)	Yaw	28	radians	3:29
(f)	Focal length	29	centimeters	8:24
(v)	Vehicle velocity	2A	meters/sec.	28:4
(ω)	Scan speed	2B	radians/sec.	2:30
(K_{IMC})*	IMC constant	2C	ratio	0:32

* The IMC constant is the amplitude of the IMC adjustment, presumably a camera setting.

$$K_{IMC} = (V/\omega\ H)_{Nominal}$$

Words 20 and 21 are not used by the program and are available for storing identifying information. All other locations of WSII are used by the computational program for storage of constants and intermediate results.

Upon completion of the input process, control should be returned to the computational program by copying channel C1 to WSIII and transferring control to word 40. The input subroutine is limited to use of Working Storages III and IV, unless the others are saved and restored upon exit from this subroutine.

Control is transferred to the output subroutine from the instruction pair of word 0E, channel C4. At present, this instruction pair (87CE 1160) uses channel CF for the mock output subroutine.

The information to be output is stored in Working Storage II in the following manner:

	QUANTITY	LOCATION	UNITS	SCALING
$(i)^*$	Designator	2D	integer	16:16
(λ_i)	Latitude	2E	radians	2:30
(θ_i)	Longitude	2F	radians	2:30

Upon completion of the output operation, control should be transferred to word 12 (channel C4 in Working Storage I). The output subroutine is limited to use of Working Storages III and IV, unless the others are saved

* $i = 1, 2, \ldots 6$

and restored upon exit from this subroutine. In operation, the program essentially mechanizes the rectification equations developed in the Broadview Research Corporation Report RB-59-2.1047-8, "Program for the Numerical Rectification of Panoramic Photography." The appropriate film coordinates of the format extrema are selected for each value of the designator (i), rectified to the object space by taking into account the orientation elements and the effects of Image Motion Compensation and vehicle motion, and the latitude and longitude of the object points are then computed. The following sketch (of the equivalent positive) shows the image points chosen as format extremities, with their corresponding designators:

VII . LIBRARY SYSTEMS FOR THE 544th RTGp.

A. Research Center Technical Library

1. The Mensuration Branch of the Research Center maintains a technical library for use by its photogrammetrists and geodesists. It was started to satisfy a Mensuration Branch need for technical information such as tables of function, mathematical formulas and technical articles in the mapping field.

The initial system of organization was a manual one requiring the typing of multiple copies of 3" X 5" library cards. At the present size of approximately 300 documents, this system has become too difficult to maintain. It should be noted that the difficulty is not due to a serious deficiency in the system, for by most standards the system is a normal one. However, the system now requires more effort than is available to operate it. A new punch card system has been devised which will lighten the clerical load involved in typing multiple cross-reference cards and file purging. The system output consists of indexes tabulated by any of the following aspects:

a. Author

b. Source (publisher)

c. Accession number

d. Subject

The subject index consists of 25 subject headings, and the indexing

is performed by personnel in the Mensuration Branch.

The system appears adequate for the local need, and in fact is run as a spare-time job (the time, manpower, and equipment involved are not part of a stated mission). Comments on the design, use, and future of the system are as follows.

2. Present Design--The subject indexing, although not detailed, is adequate for the number of documents in the collection. As this file grows, however, this will become a problem. If the number of documents increases five times, which is not unreasonable if one needs really to monitor the rapidly expanding field of geodesy and photogrammetry, the average number of documents per category might be estimated at 60. However, the distribution of new entries is never uniform, so some categories will have several times that number of references. If this is bothersome during searching, the file will fall into disuse. To remedy such a difficulty it would be necessary to re-index.

Although the file is used for general reference by a number of the technical staff in the branch, there appear to be several dominant uses which are concerned with the look-up values of trigonometric functions, specific formulae, and equipment manuals. These items can possibly be handled in another more readily accessible mode because they do not possess severe subject indexing problems and

recommendation that we explore the extension of the Mensuration library to the formation of a 544th RTGp. technical library. Possibly there are several libraries within the 544th RTGp. whose indexes (not physical documents) could be combined into a central index. This might include the Directorate of Intelligence contributions, personal collections, and other 544th RTGp. accessions. Although the adoption of such a suggestion seems doubtful, to me it makes good sense because the work done by the 544th RTGp. uses far from tried, thoroughly proven, well known techniques. Rather, it has a strong research and development flavor to it and as such needs good technical library support.

The purpose of such a central index would be to provide any user within the 544th RTGp. with the awareness of what information is on the premises. As at present the physical documents would be maintained locally and the indexing would be performed locally, but the complete index would be compiled centrally and multiple copies distributed to local user groups. Everyone would have the capability he has now, plus data on the whereabouts of other pertinent information.

All that is required to inaugurate such a system is the adoption of a standard set of input data for a document. The present Mensuration Branch system as well as any modifications we might

suggest would be entirely practical as a standard.

B. Research Center Intelligence File

Within the Research Center, textual intelligence information is received as input from outside sources for use as collateral material for the photo interpretation detailed reporting and for target study. Textual intelligence information is also generated as an output of the Analysis Center, in the form of detailed photo interpretation reports and target studies. This information is defined here as being of two types, that which has security classification up to Top Secret, and that which is higher. The Top Secret and below information is received in two ways from the Data Center - on a standard distribution basis and on a request basis. The more "sensitive" information is received only on a standard distribution basis, as far as we know. Most of the Top Secret and below information is used and returned to the Data Center. Some or all of the "sensitive" information is stored along with copies of the 544th RTGp.-produced photo interpretation reports. It is not known whether or not the target studies are stored upon completion. This file appears to be the only major textual intelligence information store within the Research Center.

A punch card retrieval system for this document store is being set up for the purpose of security control and searching. We have not been allowed complete access to this file, so the following description may be slightly in error or incomplete.

The aspects detailed in indexing are B. E., T. D. I., source type, geo-

graphic coordinates, chart number, target type, document control number, and security classification.

The searching is performed by ordinary card-sorting techniques, and tabulations are made of pertinent documents. In addition a graphic plot is made on a Benson Lehner plotter of the geographic location pertinent to the references noted in the search output. This appears to be an extremely useful technique because of the dominance of the use of geographic coordinates in searching for information.

It is difficult to suggest changes or modifications to the system without a first-hand inspection, so the following comments are made toward correction of assumed problems.

One problem which is always present is that of operating a retrieval system with minimum effort. To this end it is possible to perform a single input processing function which satisfies all tasks, present and future. Such an operation would involve log in, security control, and document receipting procedures as well as the indexing for future use.

This procedure would utilize a typed form prepared on a tape-punching typewriter. The graphic output of the process should be designed to be compatible with the required control functions. The tape output can be processed automatically to form the same type of index as is now stored. The possible advantage of a system of this type is the elimination of one or more typing or handwritten transcriptions of data from one form to another, and then onto punched cards. Paragraph E describes such a system

in greater detail.

Another problem which can occur in punched card retrieval systems is the difficulty of using a search output due to its cryptic format. In order to provide optimum punch card operations, information to be searched by sorting should be coded into as few digits as possible. Such information when printed out is usually hard to use because of its brevity. Mnenomics can be employed, but they degenerate when all of the useful combinations are exhausted or when the number of codes becomes too large for human memory reference. The solution to this problem is to carry on the card a more elaborate description (hopefully a complete English spelling) of the coded entry. This supplementary information can be used to make a more readable printout. The applicability of this solution is quite limited in the case of punched card systems because of the limited capacity of a single card, and the desirability of using the simpler single card sorting and processing systems. Trailer cards become cumbersome.

The only approach here (if the severity of the problem warrants it) is to use a more elaborate system which can handle the full English representation of document data. A system using equipment available in the 544th RTGp. Research Center is described in paragraph E.

C. Conversion of Data Center Index for "High Use" Information

One of the primary problems with existing storage and retrieval systems is that the user cannot find out at the time he requests a particular document, or more generally when he requests "information", whether or not it

will be of any use to him. The severity of the problem is dependent on the amount of time which elapses before he gets the document.

One way to improve the situation is to reduce the delivery time, and a good example of such a reduction is the impending installation of Minicard in the Data Center. Another method is to have the user himself determine the nature of the results of a search by performing a search in a local index. To perform searches locally does not require that the data preparation must be done locally. Acquisition indexing and reproduction of documents can be performed centrally (i.e. at the Data Center) and searching can be performed locally using tabulated indexes prepared locally from the central index data. Both the existing Data Center IBM system and the Minicard system can produce machine-readable index data which can be further processed by the Alwac IIIE.

Another advantage of producing a local index is that the central index data can be supplemented by local index data in those cases where the central index data is found deficient for local needs.

This procedure of producing a local index should be done only for those items with a relatively high probability of use. At present, source, type, or geographic coordinates could be used to select blocks of data from the Data Center.

With the advent of the Minicard installation, photocopies of original documents can be maintained mounted in aperture cards and stored serially in 3 X 5 manual card files. Such a system would provide immediate access to any information stored.

It should be remembered that this function duplicates a portion of the central file so the information use characteristics should be important with respect to the already mentioned points of:

1. Knowing quickly what is available.
2. Central indexing not sufficient.
3. Requirement for rapid delivery of information.

Paragraph E contains a description of how such a system could be maintained with existing Research Center equipment.

D. Mission Review Reports in Automatic Indexing of P. I. Reporting

1. Present Operation--The photo analysis section prepares two primary types of P. I. reports - a mission review report and a detailed photo intelligence report. The function of the mission review report is to provide, for dissemination, a review of all serial photography missions. This review is used by others as a tool to request specific detailed or summary reports. The detailed reports are prepared to satisfy these requests and are forwarded to the requesting agency. A common characteristic of both types of reports is that they are prepared to satisfy current needs. Therefore, it remains for an exterior central library location to maintain control of the information for future use. An exception to this is a file of target cards maintained in the photo section. These cards are made up at the time of the initial P. I. work and contain specific data about installations occurring on the photos.

Data are extracted from these cards and entered onto the mission review report. The cards are then filed by basic target type and subdivided by B. E., geographic coordinates, or T. D. I. However, much of the subject matter on the cards is not filed.

2. Proposed Changes--What is proposed is to use the mission review report as a basis for automatically generating indexes to the photography and all reports made from it. These indexes would augment the existing card file by providing access by subject. The possibility exists because the P. I. reporting language used has a very definite style. The changes involved would require typing the present mission review report on a tape-punching typewriter and subsequently processing the tapes to make indexes. A system for making these indexes is described in paragraph E.

E. Mechanization of Textual Information Handling Problems in the Research Center

1. Introduction--In the previous four paragraphs several suggestions were made toward the end of making more use of existing textual information. Such suggestions involved the use of mechanized techniques. Because the methods involved in the solutions to all suggestions are similar, a single system will be described which will satisfy all requirements. Although we describe it as a single system, we do not restrict in any way the real configuration of the system. It may consist of one, two, or many operations,

each involving one, two or many pieces of equipment. By single system, we mean that it accomplishes a common function of handling textual information.

2. Objective--The objective of the system is the mechanization of the processing of textual information in support of the functions of:

   a. Information retrieval: indexing, file maintenance, searching

   b. Publication of reports

3. System Requirements--The system must meet certain requirements in order to satisfy the objective stated above. Some of the requirements are technical or functional while others are economic.

   a. The system must operate with equipment existing within the Research Center of the 544th RTGp.

   b. System shall complement existing retrieval and reporting systems based on numerical or "exact" type data (geographic coordinates, T. D. I., B. E., photo scale, proper names, etc.).

   c. The system shall require a minimum of intellectual effort for input processing (subject indexing or language conversion function).

   d. All keypunching work done in input processing will be compatible with future system configurations.

e. Local cognizant users of information shall have immediate access to some "token" (index, abstract, extract, microfilm, etc.) of stored information.

4. Background--Files of information need to be maintained for the purpose of retrospective searching and summary reporting. Access points by which items of information can be retrieved are called "indexes", and any document information content not represented by access points (index entries) cannot be retrieved in a search. Index entries can be classed as two general types - "exact" entries and "subjective" entries. With exact entries there is no ambiguity in what is being represented, and examples of these indexes would be geographic coordinates, proper names, photo scale, photo reduction, document accession number, etc. Subjective entries, on the other hand, are words taken from their context in natural language (such as English) with the result that they convey a slightly different meaning to those who use them, depending on the exact context which the searcher applies in using them. In existing applications there is little trouble with exact type of indexes, but subject indexes are quite another another matter.

Subject indexing uses a substantial amount of intellectual effort in the selection of the best entries to represent information content. In addition, as organization interests change with time, different aspects of input information become important and the

index must be modified. This creates a requirement for re-indexing. These and other difficulties make the present systems quite deficient in responding to a subjective search and expensive to maintain. Search results are for the most part not pertinent. This rather deficient performance is made worse by the fact that document delivery of the search output is rather slow so that poor searches arrive some time after they are really needed.

5. Basic Design Approach--The first step of the approach is to extract data from the document for subsequent machine processing rather than to index, analyze or abstract it. Using this approach we are working with the actual document itself, not someone's interpretation of it. In addition, less intellectual effort is required at the input. This approach, however, requires that we have some machine methods of processing what is extracted (natural language). In the case of information which the organization itself generates, some procedures for reporting format can be devised which will make the later processing easier.

It is important in this first step to consider extracting and keypunching into machine form more data than are actually needed. This is the surest way to provide for future growth. This philosophy taken to the limit involves entry of the whole document into machine form, which at present is prohibitively expensive of keypunching and machine memory except in the case of very short documents.

The second step in the approach is to process the extracted data by machine to form the outputs of a searchable file, an index of file terms, and any other reports or accession lists that are required.

The first products of this processing may not be too much better than with existing methods, but we can be certain that better methods are continually appearing, and further, we are in a good position to adopt them without human reprocessing of data.

The third step of the basic approach is to apply human analysis to the machine processed output. It is anticipated that some of the original machine programs will be somewhat deficient in their ability to process extracted data. In the cases where machine methods are not entirely satisfactory, a human will provide corrections. If patterns to these corrections emerge, they can be incorporated into improved machine programs.

6. Detailed Design--Figure 1 illustrates the detailed functions of a processing system.

Data Extraction: This function performs the extraction of data from the input document and converts it to a machine readable form.

Query Formalization: This function formalizes an input question in terms of the index entries of the system with

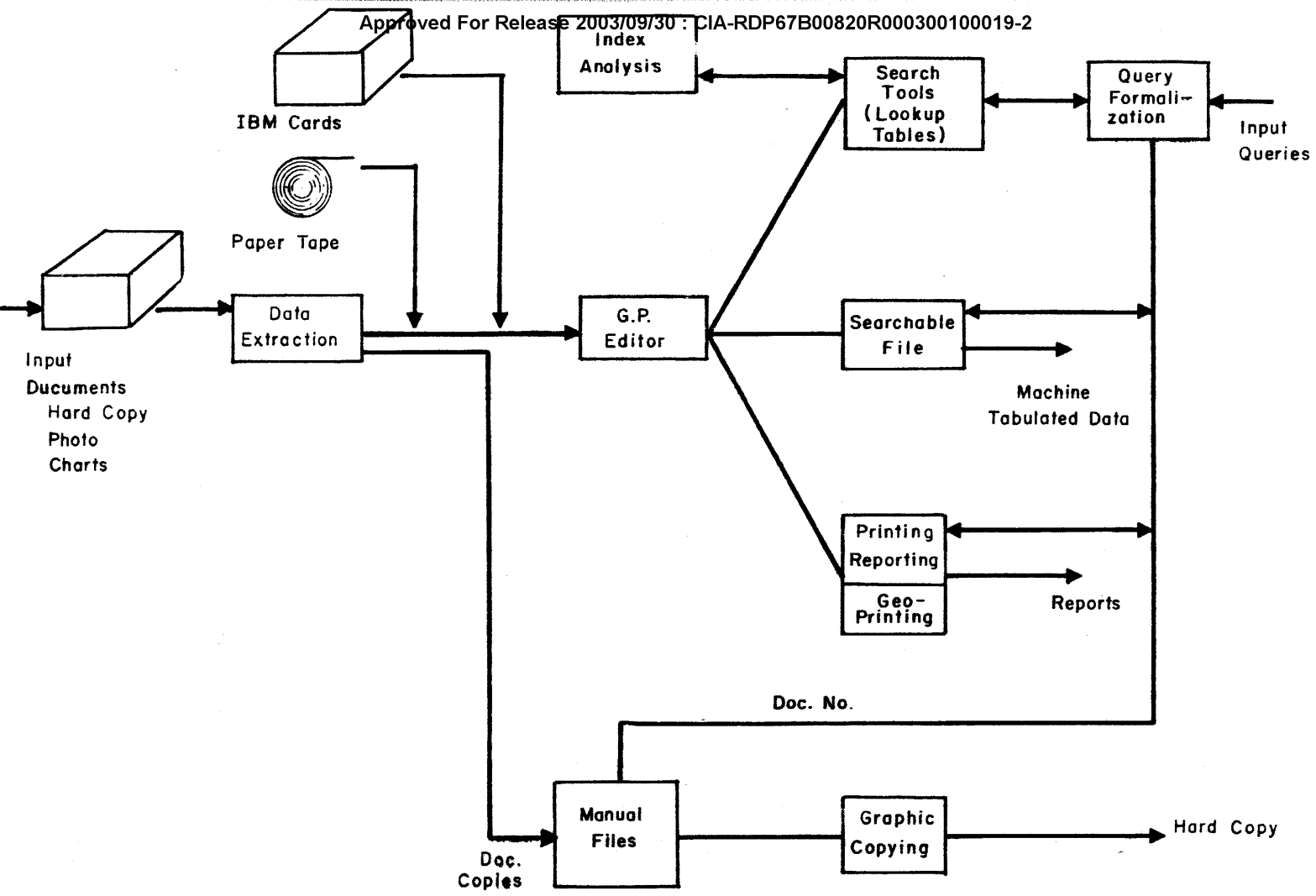


FIGURE 1

the aid of what are defined here as "searching tools". The formalized question is ready to be searched. No searching is necessary in those cases where the "tools" are used for conversion from one numbering system to another.

Search Tools (Table Lookup): Search tools are aids required to help formalize search questions. They will be tabulations or book-type listings which will function as:

a. Lists of terms used in files (eventually refined into dictionary).

b. Synonym lists (see also, thesaurus, and table conversion function).

Searchable File: The searchable file is a store of all index terms extracted from document associated with a document accession number.

Reports and Other Token Data: These are accession lists, bibliographies and other lengthy tabulations prepared directly from input data.

General Purpose Editor: This function processes the extracted input data to compile the search tools, searchable file, and reports. Its input can be locally extracted data or already keypunched punch cards and punched tape.

Index Data Analysis: This function involves the human analysis of the processed input data to form improved searching tools.

Manual Files: These files contain all documents which are felt to be important enough to be maintained locally. Typewritten documents, published reports, maps, charts, photographs, etc., will make up this file. With the advent of Minicard this file can contain a larger number of documents.

Graphic Copying: This function performs all duplicating of file copies needed.

7. Possible Applications--What has been described is an approach to processing textual data. Its applications in the 544th RTGp. Research Center will depend on a favorable ratio of the value of services provided to the costs involved. The applications are:

   a. Research Center Technical Library--Figure 2 illustrates the system applied to the Research Center technical library.

      The document input (books, technical articles, tables, and formulae) are forwarded to the extraction function. A library card is made on a tape-punching typewriter. This card has a machine readable format so that the tape output can be machine processed. The card format will contain:

      (1) Accession number

      (2) Title

      (3) Author

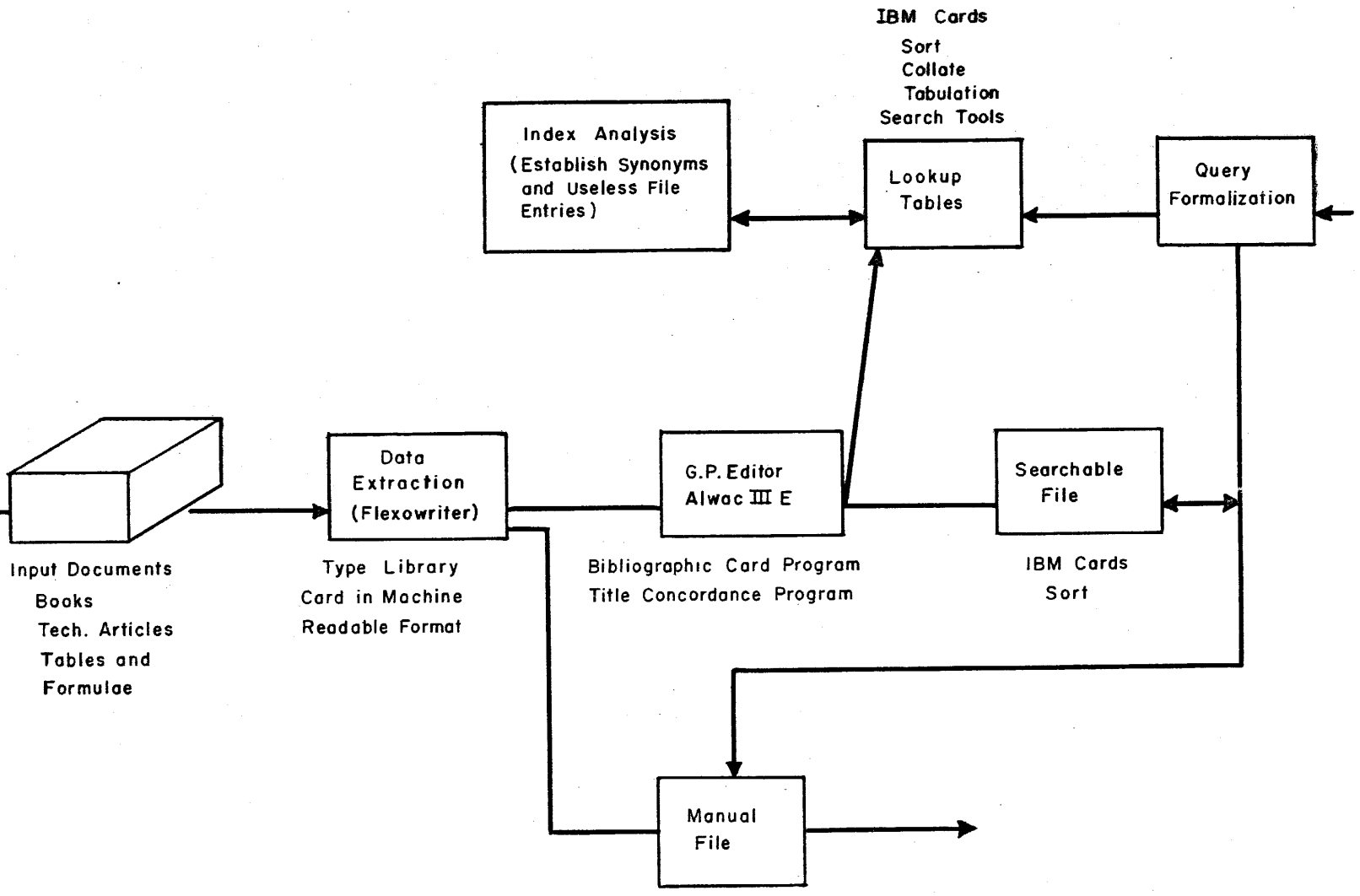


FIGURE 2

(4) Source and/or author affiliation

(5) Subject headings

(6) Name and location of owner of publication, if other than Research Center

It might be advisable to treat each chapter of a book as a technical article in order to help make more uniform the scope of information content of the items handled.

The machine editing function is performed by the Alwac IIIE which accepts the prepared paper tape and produces the following types of IBM card decks which are sorted, collated, and tabulated:

(1) Author

(2) Source and affiliation

(3) Subject heading

(4) Title and title concordance (if desired)

Another deck, sorted by accession number and containing name and location of document owner as well as abbreviated title and author, is used as a searchable file. Although this function could be performed on the Alwac IIIE, the size of the operation cannot justify its efficient use.

b. Research Center Intelligence File--Figure 3 illustrates the system application to the Research Center intelligence

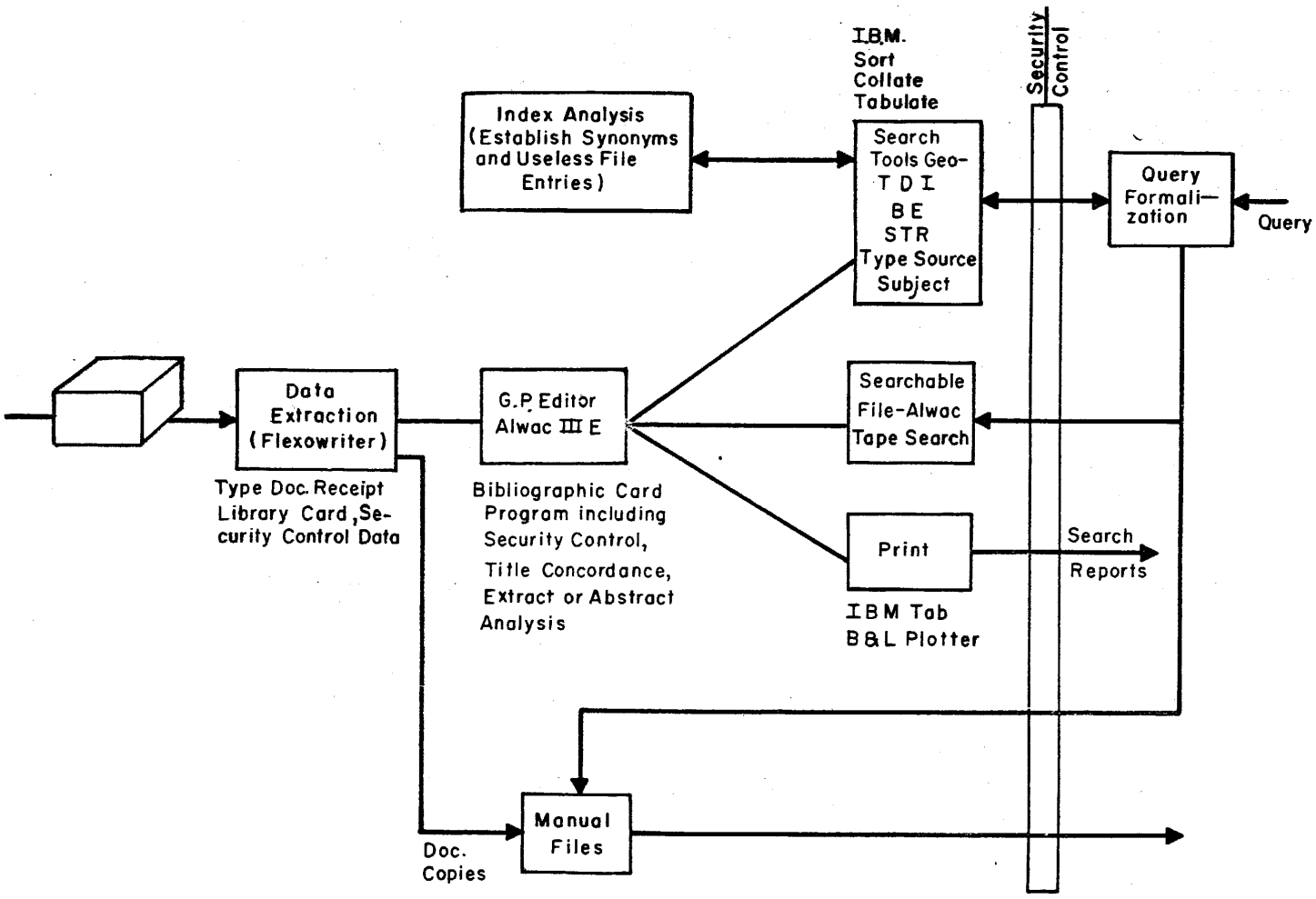


FIGURE 3

file. It is similar to the previous example with the following exceptions. Security control data processing is combined with the data extraction function and control logs are maintained in the same manner as indexes. If a good title does not appear on the incoming document, sentences within the document which best represent the document should be used as a title. As a last resort a title should be written. It may be advisable to extract a paragraph (document abstract if one appears) to supplement title data for printout and future searching purposes, although security restrictions might encumber the excessive use of extracted data. The extracted data are Alwac IIIE processed to form IBM decks for tabulation according to the highly used search aspects (for example, B. E. or T. D. I. or target type). A searchable file is prepared on the Alwac IIIE for the unusual search or complex search. Tabulated printouts can be made from either the Alwac IIIE or the IBM table lookup decks.

The text analysis performed by the Alwac IIIE would involve searching and extracting as indexes important proper nouns, and other text constructions which have a high probability of representing the information content of the report.

c. Conversion of Data Center Index to Local Index--Figure 4 illustrates the data flow required to convert the 544th RTGp. central indexes to local indexes. The information to be processed would be specified by a general category such as source or location or ISC classification entry. The hard copy or mounted Minicards would be delivered along with a duplicate index data punched tape or punch card deck. These data would be Alwac IIIE processed and combined with any local indexes to form an IBM-tabulated quick reference index. Complex searches (searches involving logical combination of several items) would be performed at the Data Center, but table lookup or quick reference indexes would be available locally. If the priority warranted it, complex searches could be made locally on the Alwac IIIE (dotted lines, Figure 4).

d. Automatic Indexing of P. I. Reporting--Figure 5 illustrates the information flow required to perform automatic indexing of mission review report data. At the time of typing the mission review report, a punched tape is produced. This tape is Alwac IIIE processed to form a deck of IBM cards for tabulation purposes, and a searchable file. The indexes so prepared can be used for other reports derived from the same photography through the use of the mission number reference.

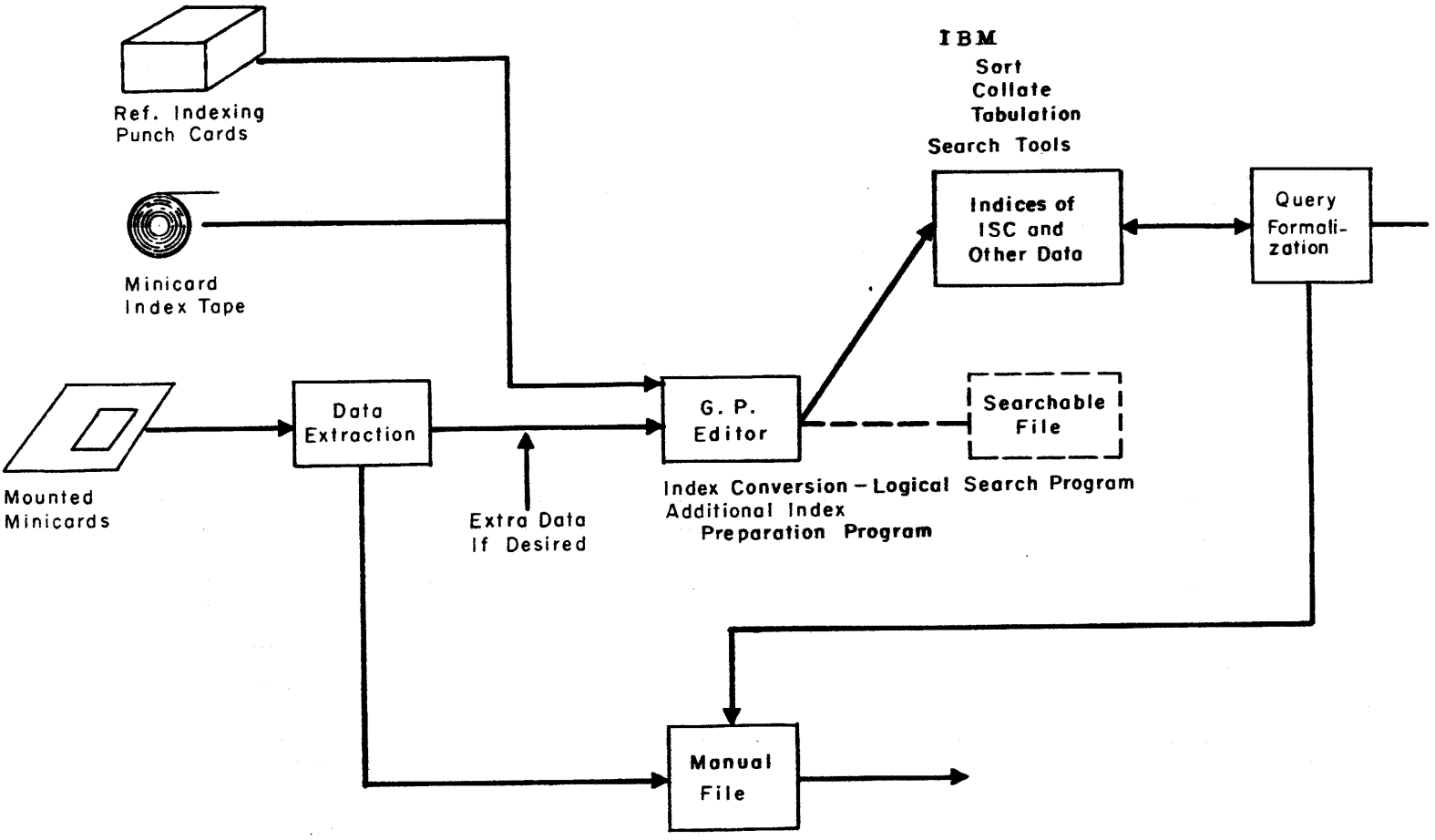
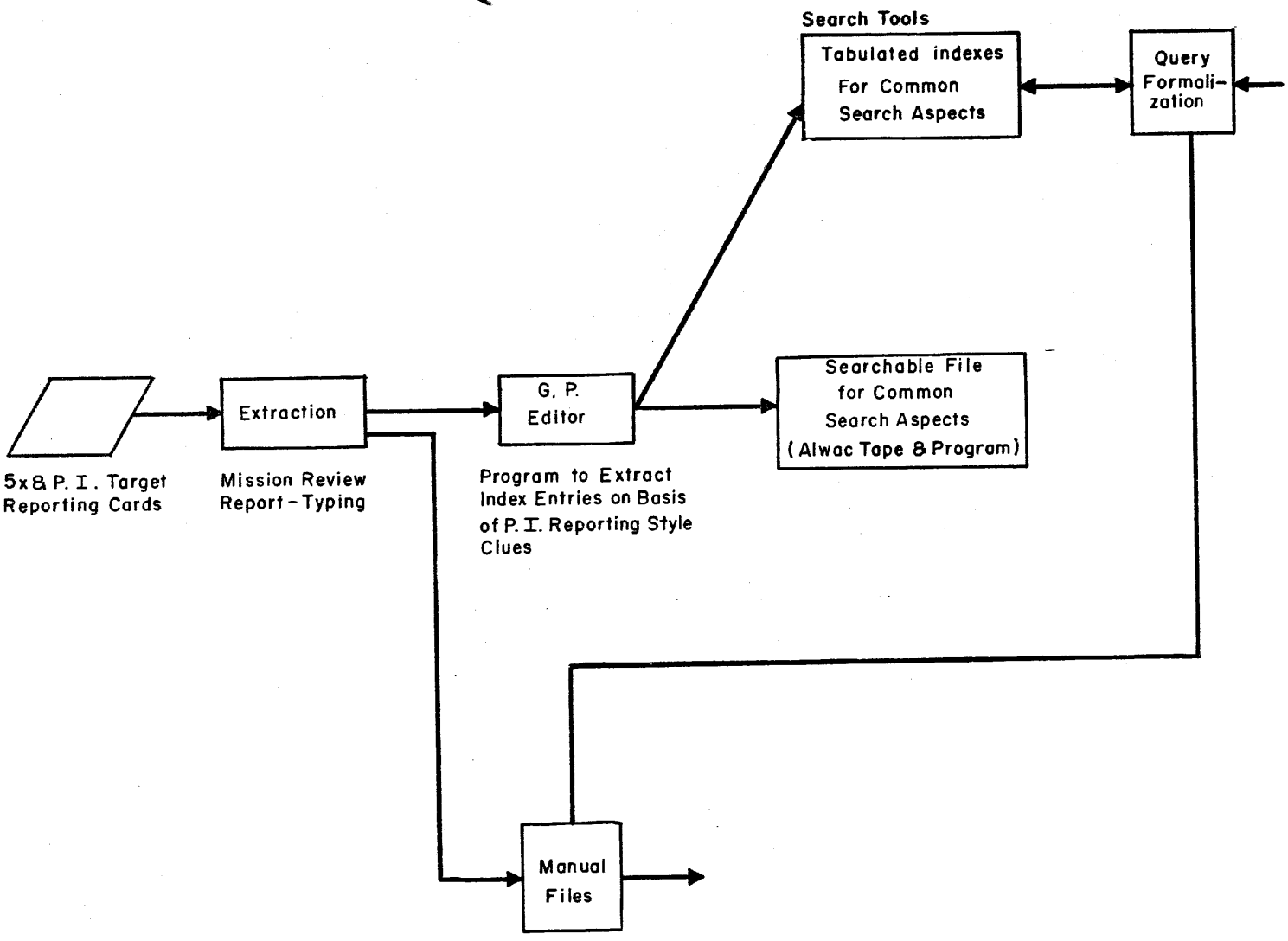


FIGURE 4



8. Textual Information Input Format For Alwac IIIE--All of the above systems involve a textual input to the Alwac IIIE. There are two types: (1) previously prepared data obtained from the Data Center, such as Minicard index tape, and (2) data prepared at the Research Center as an output of a normal typing operation. The previously prepared data will have a format when delivered, and programs can be written to accommodate this format. The format control will be determined by specified fielding on punch cards or special symbols and fixed-length symbol sequences on paper tape. The Alwac IIIE programs should be devised to convert this format to any desired output.

The punched tape formed as a by-product of a Research Center operation will have a format determined by the graphic format in which the typing is prepared. The Alwac IIIE programs used will recognize sequences of non-printing format control symbols such as carriage returns, tabs, spaces, multiple spaces, and backspaces. In addition, printing keyboard symbols may be assigned special purposes, but if this is done excessively, the graphic output will be impaired.

9. Summary of Possible Alwac IIIE Textual Information Processing Programs--

Bibliographic card and title concordance program: converts paper tape to multiple copies and punch cards for sorting,

collating and tabulating into table lookup indexes.

Index data storage program: stores data on Alwac IIIE tape for later searching.

Index searching program: searches data on basis of logical combinations of index terms.

Security control program: supplements bibliographic card program to establish document inventory processing methods.

Output printing program: converts abbreviated stored data into more readable output printing. Complements already established geographic plotting printing.

Text analysis program: searches for code words and text constructions and converts them to standard indexes.

Index conversion program: converts ISC, numerical and Data Center numerical indexes to more readable alphabetical subject heading index.

F. Programming and Computer Usage

1. Compilers and Symbolic Programming--Aerotriangulation, coordinate conversion, and rectification are the primary computing tasks involved in photogrammetry. They are numerical problems, and have a well defined scope. In such a situation symbolic programming can be used to an advantage if many programs are needed.

Considerable effort is involved in writing a compiler, but from a

long range viewpoint it seems worthwhile. However, each time a new type of computer is installed, a new compiler must be written. Therefore, in planning any sort of compiler, the number of programs and the computer workload (as it affects any decision to acquire additional different computation equipment) must be taken into consideration.

2. Program Translators--When identical computations are to be carried out on different computers, two sets of programs are required. Programs can be written for both machines, or a program translator can be developed. Program translators operate in one direction only so all programs must be written on one of the two machines. The decision to write a translator depends on the relative effort of writing the translator compared to the effort involved in rewriting the programs. The effort involved in rewriting programs is proportional to the number of programs which would need to be operable on the two machines and the difficulty of writing a program for the machine in question.

3. Computer User Groups and Special Machines--In running a computer operation there is much benefit to be gained from the study and use of already prepared programs. Most computer corporations foster organizations known as "user groups" whose purpose is the exchange of computer programs. In the case of the Alwac IIIE, the group is a small one due to the small number of machines in

use and also due to the fact that all the Alwacs are not the same, there being several modifications. The Recomp II, on the other hand, has a rapidly expanding user group, and as of this date several compilers are available. Because the SAC Recomp is being modified to contain tape units, new instructions will be added to the machine. Although these new instructions will not alter the basic machine operation, it remains to be seen whether commercial versions of Recomp II tape machines will be the same as the 544th RTGp. machine. If they are not, then part of the usefulness of the user group pertinent to tape unit operation is lost.

If any future use of the Research Center computers involves a great deal of general data processing such as that required to process actual information, a sorting capability will be needed. Both the present Alwac IIIE and the intended Recomp modification have only two tape units and, therefore, will not have a high sorting capability.

G. Summary of Recommendations

1. If the Research Center future use of the Alwac centers around a few programs, then an Alwac compiler is not warranted.
2. A program translator from the Alwac to the Recomp is not warranted because it will be easier to rewrite programs on the Recomp than to write a translator.
3. An accurate study of the future workload should be made, for it

directly affects decisions to write programs, compilers, and translators.

4. If the future Research Center work involves sorting, the present and anticipated machines will be quite slow.

5. In general it is a good idea to use machines which are used by others in order to take advantage of programs written by others. Special configurations of machines have disadvantages in this respect.

VIII. FUTURE PLANS

A. Photogrammetric Techniques and Equipment

The immediate future will be spent in a detailed analysis of the results of the control extension tests which were conducted and the results from this analysis should indicate the limitations to which a technique of this type is applicable to the operational problems concerning the 544th RTGp at this time.

Although the studies conducted under this program to date have dealt more or less directly with the immediate problems at hand and methods of handling the inputs which are available today, it is apparent that some new and entirely different inputs may be available in the future. During the next reporting period, it is intended that some of these new inputs will be studied, the methods and equipment required for handling these and for obtaining from them the basic information required will be investigated.

In this concept, it is not unreasonable to assume that some future reconnaissance systems may utilize the high resolution capabilities of a panoramic-type camera. Mensuration and interpretation of this unique presentation will require new approaches and possibly new equipment. Further, some adaptations from Dr. Santoni's solar triangulation system may be encountered. He has suggested the possible use of star photographs concurrent with the ground photography. This effort would require special training in the use of star charts as well as new computational schemes. These are only two of many possible new and unique collection systems. It is imperative that

a use capability be established for all possible inputs prior to the delivery of the reconnaissance material.

B. Photographic Techniques and Equipment

The analysis of the resolution tests on the various printers and enlargers will be completed during the next period. Analysis of the tests conducted with Project [redacted] photography will also be completed and these results will be correlated with the results of the resolution tests. Further, it is planned to conduct both series of tests on the LogEtronic SP 10/70 Printer which was not available earlier.

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Laboratory tests, including sensitometry, spectral sensitivity, and resolution, will be made on the new SO-278 film which Eastman Kodak is recommending for use in all optical printers. (A portion of this work has already been done.) These data, in comparison with the presently used duplicating materials, will be included in the final report.

C. Photogrammetric Computer Programs

During the next reporting period, the computer programming group will be expended toward the complete debugging of the programs already written and development of further programs as specified by the other disciplines of this group. These programs will be applicable to the immediate problems of the Research Center as well as the future problems of the entire SAC effort. In this respect, many of the programs required, cannot be specified prior to the completion of the investigative phases of this program. Therefore, the programming efforts will be continued

after the major portion of the program has been completed. A complete list of recommended programs and their application will be included in the final report on this project.

D. Library Techniques and Methods

Further development of the library systems introduced in Chapter VII of this report will be explored during the final phase of this program. Following a directive from SAC as to the considered applicability of the proposed systems, the details of the efforts required for implementation will be developed.

E. Analysis of Future Photo Inputs

During the next period, an analysis will be made of photographic inputs from future advanced reconnaissance systems, e.g. E-2, E-5, etc., and the impact of these on the capabilities and operations of the 544th RTGp and related units. This analysis will include a review of the equipment and techniques required for optimum photo reproduction and photointerpretation and photogrammetric exploitation of these inputs. A general system will be recommended which will include details concerning equipment, techniques, work flow and operational concept.

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APPENDIX E

Change in Scope in Photo Interpretation Area

At the review meeting on the first interim report held on June 14, all problems were resolved with the exception of the special PI area. This was deferred for further discussion and decision to a meeting held on June 15, to be attended by personnel from [redacted] along with D/I and 544th RTGp representatives.

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At this 15 June meeting, [redacted] of [redacted] and Col. Tighe of the 544th RTGp stated that the exposure which was given to [redacted] on June 8 was entirely inadequate to allow Itek to carry out its assignment in this area, and further that it would be impossible to do this unless unrestricted access were granted. [redacted] gave the following reasons:

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1. [redacted] personnel were exposed to only a small fraction of the usual volume of materials, so that no observation of the impact of very large quantities to be examined in a short length of time was possible.
2. Because the operation was simulated, the group was not motivated to work rapidly under a real sense of urgency. There was no pressure to complete a large amount of work in a given period of time.
3. The material under study was not truly representative, because it consisted of pre-selected prints (based on an already completed MRPIR) which had a much higher than normal percentage of targets.

Thus, no indication was had of the time normally spent in searching non-productive areas.

4. An incomplete exposure to the collateral normally used was had.

5. Because only one work order to the Special Photo Lab for enlargements and stereo transparencies was processed, it was impossible to tell whether the quality which was obtained in this single response (an excellent enlargement resulted) was truly indicative of the quality that prevails when hundreds of such enlargements are requested over a short period.

6. The photo quality on the selected prints we observed was quite erratic. Several instances of severe blurring from poor contact during printing were observed, and tone reproduction was poor. However, we found that very probably these were made on equipment that is no longer used. (A striking difference in quality was noted between the old contact print and the new enlargement.)

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Col. Krause asked Col. Tighe, Col. McCash, Maj. Anderson, and [redacted] in turn, whether they all agreed that unrestricted access would be required to carry out the study in the special PI area. The answer from all was unanimously "yes." He then proposed that this portion of the study be deleted from the 544th RTGp work statement. This was agreed.

Col. McCash and Maj. Anderson then asked that the PI effort be directed to the Target Materials Division PI and cartographic shops, were the special clearance problem did not exist. Emphasis could be placed on

bringing these PI groups up in techniques, equipment on improving the techniques, equipment and training for these groups, possibly by suggesting adoption of certain practices and equipment already in use in the special PI shop of the Research Center. Also, a broader spectrum of photo inputs and products prevails in this area, with small scale and poor quality frequently limiting the intelligence to be derived. This was agreed by Itek.

A wire to AFCIN was to be sent by the Target Materials Division notifying the deletion of the portion of the 544th RTGp work statement dealing with the special PI area.